Assignment 3: SDN and RYU(2023CSZ8077)

PART 1

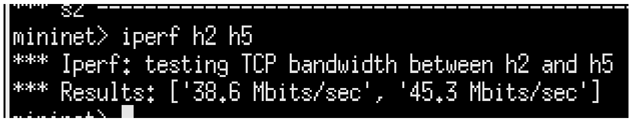
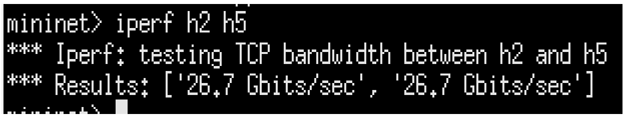
1.In both scenarios, conducting 3 pings for each case. Report the latency values. Explain the observed latency differences between the Hub Controller and Learning Switch. Also, explain differences (if any) observed between h2 and h5 for both controller types.

ping	Latency in hub_controller(milliseconds)	Latency in Learning switch(milliseconds)
H1 ping h2	1.44,1.45,1.37	7.64,0.186,0.085
H2 ping h1	1.88,1.33,1.33	0.217,0.061,0.064
H1 ping h3	1.87,1.30,1.33	4.91, 0.063,0.051
H1 ping h4	2.62,1.92,2.01	11.1, 0.205,0.068
H1 ping h5	2.50,2.04,1.97	14.8,0.064,0.054
H2 ping h3	1.88,1.43,1.43	9.94, 0.049,0.061
H2 ping h4	2.59,2.23,2.18	17.1,0.065,0.065
H2 ping h5	2.68,1.96,2.04	17.7,0.051,0.046
H3 ping h1	1.77,1.30,1.39	0.214,0.043,0.053
H3 ping h2	1.35,1.62,1.44	0.218,0.076,0.063
H3 ping h4	2.75,2.09,2.03	17.7,0.067,0.068
H3 ping h5	2.62,2.05,2.05	14.7,0.066,0.055
H4 ping h1	2.61,2.13,2.03	0.256,0.067,0.066
H4 ping h2	2.44,2.09,2.04	0.253,0.082,0.066
H4 ping h3	2.10,2.12,2.14	0.258,0.062,0.07
H4 ping h5	1.89,1.64,1.45	5.25,0.061,0.077
H5 ping h1	2.53,1.18,2.25	0.262,0.068,0.069
H5 ping h2	2.64,2.05,2.11	0.261,0.082,0.055
H5 ping h3	2.57,2.09,1.77	0.26,0.052,0.082
H5 ping h4	1.48,1.54,1.57	0.211,0.063,0.063

In case of hub controller, the ping packets are flooded to all other ports except the incoming port, so the latency for every ping is almost same. However, in case of learning switch the MAC address and port mapping are learned first. The switch keeps a mapping of MAC and port. If the port for the destination MAC is stored on the switch, the packet is simply forwarded. Else, the switch floods the packet to all other ports. The ping reply from the host triggers storing the port to MAC mapping at the switch. Thus, when new packet comes for the destination MAC,the port is known and the packet is simply forwarded reducing the latency to very low values as can be seen in the table. Thus, the latency for learning switch is higher for the first time only when the port mapping is unknown. When the port mapping is available the MAC, only one packet is forwarded to the destination MAC reducing the latency to very low value.

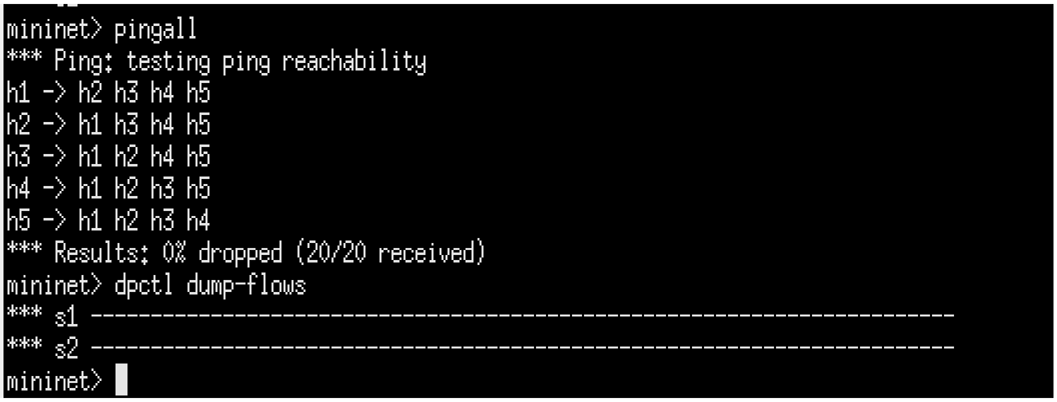
Host H2 and H4 are connected via two switches, thus the latency value is higher for ping requests between the two hosts vis-a-vis hosts connected through the same switch say, H1 and H2. This is due to the delay(queuing and propagation) at the two switches.

2. Run a throughput test between h1 and h5. Report the observed values. Explain the differences between the Hub Controller and Learning Switch.

Hub_controller	Learning switch
 *** s2 -- mininet> iperf h2 h5 *** Iperf: testing TCP bandwidth between h2 and h5 *** Results: ['38.6 Mbits/sec', '45.3 Mbits/sec'] mininet>	 mininet> iperf h2 h5 *** Iperf: testing TCP bandwidth between h2 and h5 *** Results: ['26.7 Gbits/sec', '26.7 Gbits/sec'] mininet>

Hub controller simply floods the packets to all the non-incoming ports. This increases the traffic and introduces **additional processing and queuing delay** at the switches which in turn reduces the throughput. However, after learning the port to MAC mapping in learning switch, packet is only forwarded to the destination MAC at the connected port. So, the throughput is higher.

3. Run pingall in both cases and report the installed rules on switches.



```
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5
h2 -> h1 h3 h4 h5
h3 -> h1 h2 h4 h5
h4 -> h1 h2 h3 h5
h5 -> h1 h2 h3 h4
*** Results: 0% dropped (20/20 received)
mininet> dpctl dump-flows
*** s1 ------------------------------------------------------------------------
*** s2 ------------------------------------------------------------------------
mininet>
```

Rules on switch for hub controller

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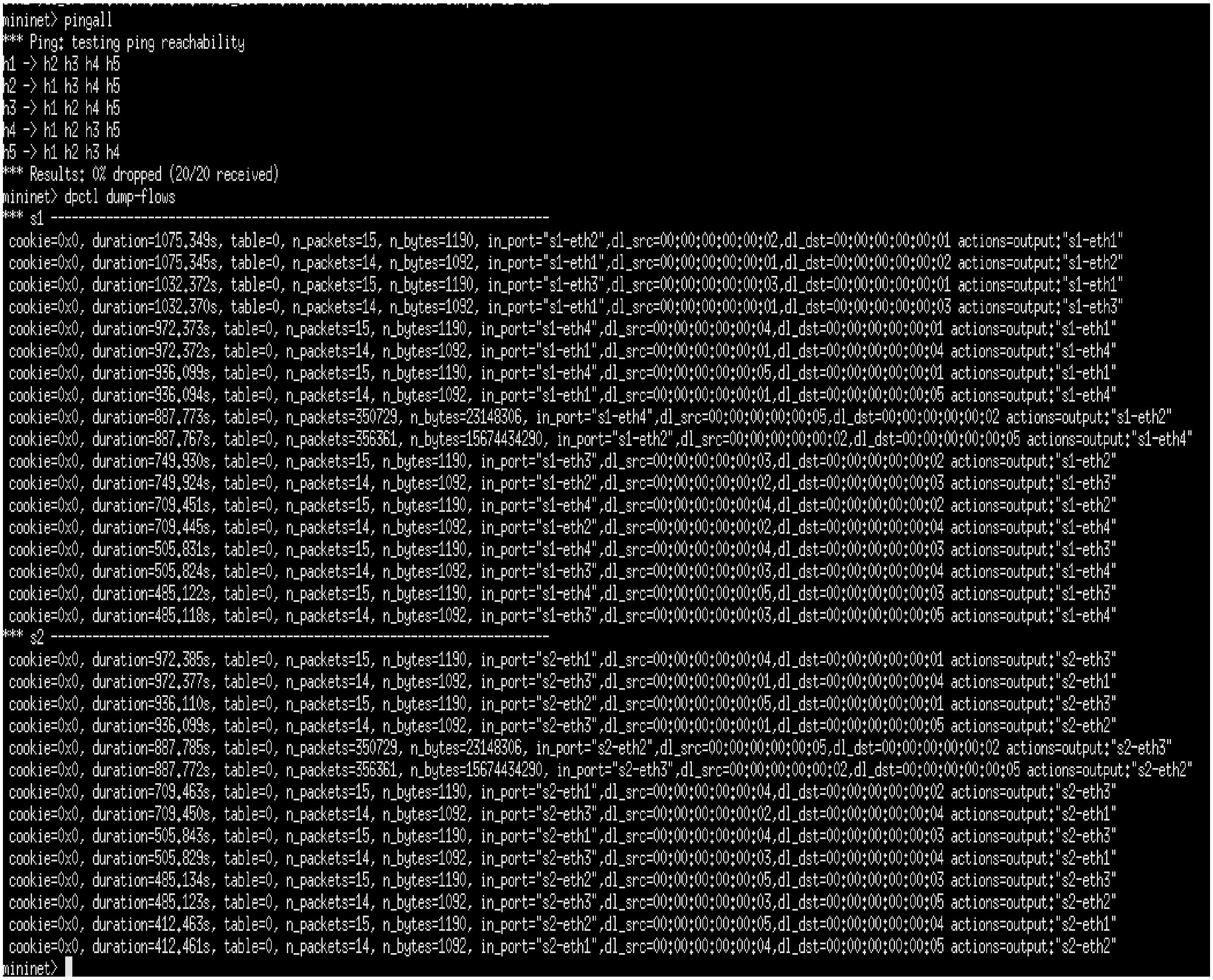
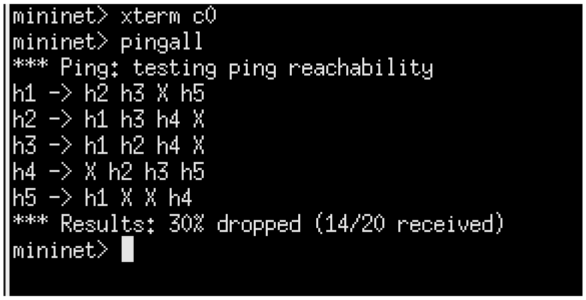


```
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5
h2 -> h1 h3 h4 h5
h3 -> h1 h2 h4 h5
h4 -> h1 h2 h3 h5
h5 -> h1 h2 h3 h4
*** Results: 0% dropped (20/20 received)
mininet> dpctl dump-flows
*** s1 ------------------------------------------------------------------------
 cookie=0x0, duration=1075.349s, table=0, n_packets=15, n_bytes=1190, in_port="s1-eth2",dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:01 actions=output:"s1-eth1"
 cookie=0x0, duration=1075.345s, table=0, n_packets=14, n_bytes=1092, in_port="s1-eth1",dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:02 actions=output:"s1-eth2"
 cookie=0x0, duration=1032.372s, table=0, n_packets=15, n_bytes=1190, in_port="s1-eth3",dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:01 actions=output:"s1-eth1"
 cookie=0x0, duration=1032.370s, table=0, n_packets=14, n_bytes=1092, in_port="s1-eth1",dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:03 actions=output:"s1-eth3"
 cookie=0x0, duration=972.373s, table=0, n_packets=15, n_bytes=1190, in_port="s1-eth4",dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:01 actions=output:"s1-eth1"
 cookie=0x0, duration=972.372s, table=0, n_packets=14, n_bytes=1092, in_port="s1-eth1",dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:04 actions=output:"s1-eth4"
 cookie=0x0, duration=936.099s, table=0, n_packets=15, n_bytes=1190, in_port="s1-eth4",dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:01 actions=output:"s1-eth1"
 cookie=0x0, duration=936.094s, table=0, n_packets=14, n_bytes=1092, in_port="s1-eth1",dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:05 actions=output:"s1-eth4"
 cookie=0x0, duration=887.773s, table=0, n_packets=350729, n_bytes=23148306, in_port="s1-eth4",dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:02 actions=output:"s1-eth2"
 cookie=0x0, duration=887.767s, table=0, n_packets=356361, n_bytes=15674434290, in_port="s1-eth2",dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:05 actions=output:"s1-eth4"
 cookie=0x0, duration=749.930s, table=0, n_packets=15, n_bytes=1190, in_port="s1-eth3",dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:02 actions=output:"s1-eth2"
 cookie=0x0, duration=749.924s, table=0, n_packets=14, n_bytes=1092, in_port="s1-eth2",dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:03 actions=output:"s1-eth3"
 cookie=0x0, duration=709.451s, table=0, n_packets=15, n_bytes=1190, in_port="s1-eth4",dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:02 actions=output:"s1-eth2"
 cookie=0x0, duration=709.445s, table=0, n_packets=14, n_bytes=1092, in_port="s1-eth2",dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:04 actions=output:"s1-eth4"
 cookie=0x0, duration=505.831s, table=0, n_packets=15, n_bytes=1190, in_port="s1-eth4",dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:03 actions=output:"s1-eth3"
 cookie=0x0, duration=505.824s, table=0, n_packets=14, n_bytes=1092, in_port="s1-eth3",dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:04 actions=output:"s1-eth4"
 cookie=0x0, duration=485.122s, table=0, n_packets=15, n_bytes=1190, in_port="s1-eth4",dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:03 actions=output:"s1-eth3"
 cookie=0x0, duration=485.118s, table=0, n_packets=14, n_bytes=1092, in_port="s1-eth3",dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:05 actions=output:"s1-eth4"
*** s2 ------------------------------------------------------------------------
 cookie=0x0, duration=972.385s, table=0, n_packets=15, n_bytes=1190, in_port="s2-eth1",dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:01 actions=output:"s2-eth3"
 cookie=0x0, duration=972.377s, table=0, n_packets=14, n_bytes=1092, in_port="s2-eth3",dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:04 actions=output:"s2-eth1"
 cookie=0x0, duration=936.110s, table=0, n_packets=15, n_bytes=1190, in_port="s2-eth2",dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:01 actions=output:"s2-eth3"
 cookie=0x0, duration=936.099s, table=0, n_packets=14, n_bytes=1092, in_port="s2-eth3",dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:05 actions=output:"s2-eth2"
 cookie=0x0, duration=887.785s, table=0, n_packets=350729, n_bytes=23148306, in_port="s2-eth2",dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:02 actions=output:"s2-eth3"
 cookie=0x0, duration=887.772s, table=0, n_packets=356361, n_bytes=15674434290, in_port="s2-eth3",dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:05 actions=output:"s2-eth2"
 cookie=0x0, duration=709.463s, table=0, n_packets=15, n_bytes=1190, in_port="s2-eth1",dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:02 actions=output:"s2-eth3"
 cookie=0x0, duration=709.450s, table=0, n_packets=14, n_bytes=1092, in_port="s2-eth3",dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:04 actions=output:"s2-eth1"
 cookie=0x0, duration=505.843s, table=0, n_packets=15, n_bytes=1190, in_port="s2-eth1",dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:03 actions=output:"s2-eth3"
 cookie=0x0, duration=505.829s, table=0, n_packets=14, n_bytes=1092, in_port="s2-eth3",dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:04 actions=output:"s2-eth1"
 cookie=0x0, duration=485.134s, table=0, n_packets=15, n_bytes=1190, in_port="s2-eth2",dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:03 actions=output:"s2-eth3"
 cookie=0x0, duration=485.123s, table=0, n_packets=14, n_bytes=1092, in_port="s2-eth3",dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:05 actions=output:"s2-eth2"
 cookie=0x0, duration=412.463s, table=0, n_packets=15, n_bytes=1190, in_port="s2-eth2",dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:04 actions=output:"s2-eth1"
 cookie=0x0, duration=412.461s, table=0, n_packets=14, n_bytes=1092, in_port="s2-eth1",dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:05 actions=output:"s2-eth2"
mininet>
```

Rules on switch for Learning Switch

PART 2

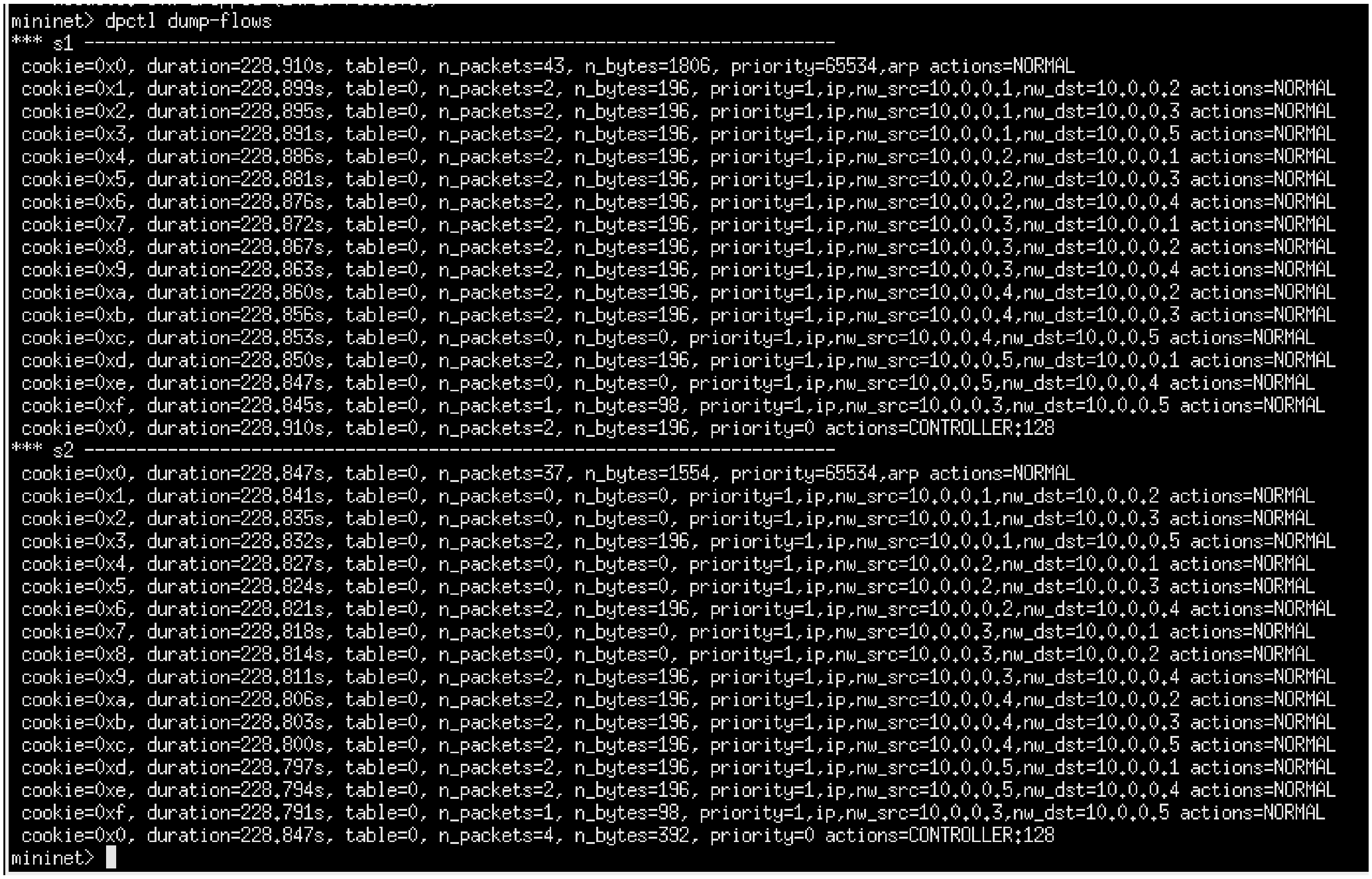
1. Run pingall and report the results.



```
mininet> xterm c0
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 X h5
h2 -> h1 h3 h4 X
h3 -> h1 h2 h4 X
h4 -> X h2 h3 h5
h5 -> h1 X X h4
*** Results: 30% dropped (14/20 received)
mininet>
```

Assignment 3: SDN and RYU(2023CSZ8077)

2. Report the installed rules on both switches. Can you think of ways to minimize the number of firewall rules on the switch?



```
mininet> dpctl dump-flows
*** s1 ------------------------------------------------------------------------
 cookie=0x0, duration=228.910s, table=0, n_packets=43, n_bytes=1806, priority=65534,arp actions=NORMAL
 cookie=0x1, duration=228.899s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.1,nw_dst=10.0.0.2 actions=NORMAL
 cookie=0x2, duration=228.895s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.1,nw_dst=10.0.0.3 actions=NORMAL
 cookie=0x3, duration=228.891s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.1,nw_dst=10.0.0.5 actions=NORMAL
 cookie=0x4, duration=228.886s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.2,nw_dst=10.0.0.1 actions=NORMAL
 cookie=0x5, duration=228.881s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.2,nw_dst=10.0.0.3 actions=NORMAL
 cookie=0x6, duration=228.876s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.2,nw_dst=10.0.0.4 actions=NORMAL
 cookie=0x7, duration=228.872s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.3,nw_dst=10.0.0.1 actions=NORMAL
 cookie=0x8, duration=228.867s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.3,nw_dst=10.0.0.2 actions=NORMAL
 cookie=0x9, duration=228.863s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.3,nw_dst=10.0.0.4 actions=NORMAL
 cookie=0xa, duration=228.860s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.4,nw_dst=10.0.0.2 actions=NORMAL
 cookie=0xb, duration=228.856s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.4,nw_dst=10.0.0.3 actions=NORMAL
 cookie=0xc, duration=228.853s, table=0, n_packets=0, n_bytes=0, priority=1,ip,nw_src=10.0.0.4,nw_dst=10.0.0.5 actions=NORMAL
 cookie=0xd, duration=228.850s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.5,nw_dst=10.0.0.1 actions=NORMAL
 cookie=0xe, duration=228.847s, table=0, n_packets=0, n_bytes=0, priority=1,ip,nw_src=10.0.0.5,nw_dst=10.0.0.4 actions=NORMAL
 cookie=0xf, duration=228.845s, table=0, n_packets=1, n_bytes=98, priority=1,ip,nw_src=10.0.0.3,nw_dst=10.0.0.5 actions=NORMAL
 cookie=0x0, duration=228.910s, table=0, n_packets=2, n_bytes=196, priority=0 actions=CONTROLLER:128
*** s2 ------------------------------------------------------------------------
 cookie=0x0, duration=228.847s, table=0, n_packets=37, n_bytes=1554, priority=65534,arp actions=NORMAL
 cookie=0x1, duration=228.841s, table=0, n_packets=0, n_bytes=0, priority=1,ip,nw_src=10.0.0.1,nw_dst=10.0.0.2 actions=NORMAL
 cookie=0x2, duration=228.835s, table=0, n_packets=0, n_bytes=0, priority=1,ip,nw_src=10.0.0.1,nw_dst=10.0.0.3 actions=NORMAL
 cookie=0x3, duration=228.832s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.1,nw_dst=10.0.0.5 actions=NORMAL
 cookie=0x4, duration=228.827s, table=0, n_packets=0, n_bytes=0, priority=1,ip,nw_src=10.0.0.2,nw_dst=10.0.0.1 actions=NORMAL
 cookie=0x5, duration=228.824s, table=0, n_packets=0, n_bytes=0, priority=1,ip,nw_src=10.0.0.2,nw_dst=10.0.0.3 actions=NORMAL
 cookie=0x6, duration=228.821s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.2,nw_dst=10.0.0.4 actions=NORMAL
 cookie=0x7, duration=228.818s, table=0, n_packets=0, n_bytes=0, priority=1,ip,nw_src=10.0.0.3,nw_dst=10.0.0.1 actions=NORMAL
 cookie=0x8, duration=228.814s, table=0, n_packets=0, n_bytes=0, priority=1,ip,nw_src=10.0.0.3,nw_dst=10.0.0.2 actions=NORMAL
 cookie=0x9, duration=228.811s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.3,nw_dst=10.0.0.4 actions=NORMAL
 cookie=0xa, duration=228.806s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.4,nw_dst=10.0.0.2 actions=NORMAL
 cookie=0xb, duration=228.803s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.4,nw_dst=10.0.0.3 actions=NORMAL
 cookie=0xc, duration=228.800s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.4,nw_dst=10.0.0.5 actions=NORMAL
 cookie=0xd, duration=228.797s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.5,nw_dst=10.0.0.1 actions=NORMAL
 cookie=0xe, duration=228.794s, table=0, n_packets=2, n_bytes=196, priority=1,ip,nw_src=10.0.0.5,nw_dst=10.0.0.4 actions=NORMAL
 cookie=0xf, duration=228.791s, table=0, n_packets=1, n_bytes=98, priority=1,ip,nw_src=10.0.0.3,nw_dst=10.0.0.5 actions=NORMAL
 cookie=0x0, duration=228.847s, table=0, n_packets=4, n_bytes=392, priority=0 actions=CONTROLLER:128
mininet> █
```

Rules installed on the switch

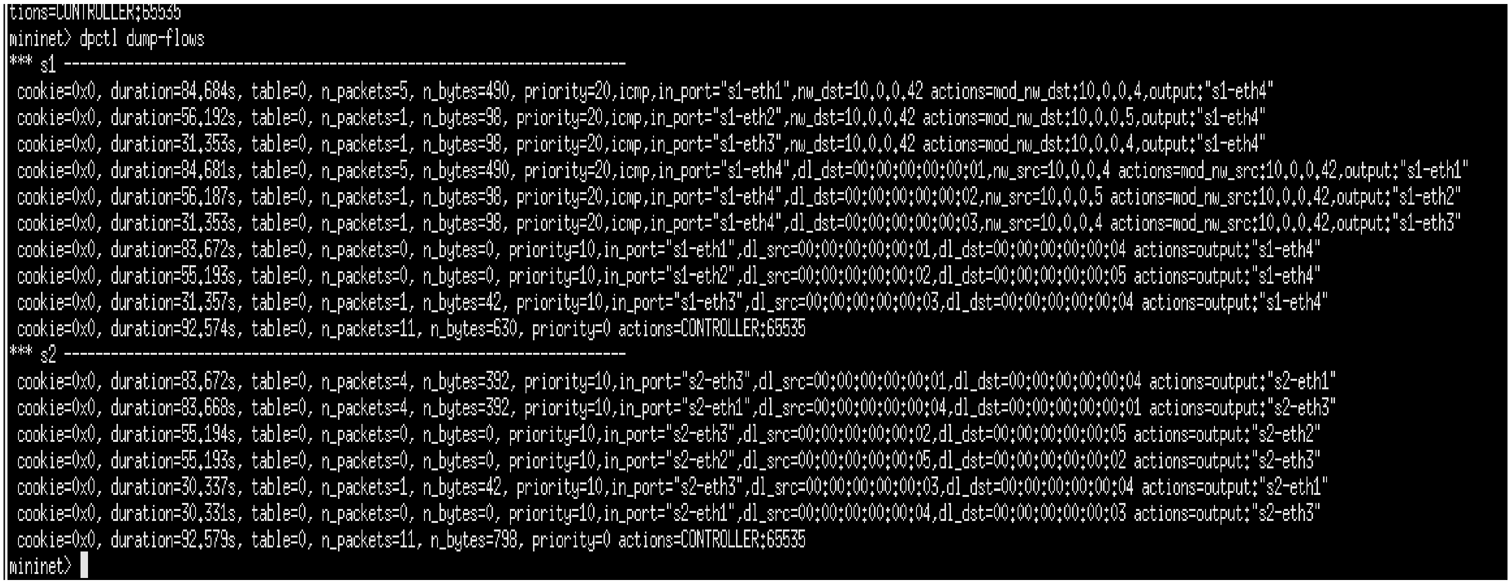
Ways to minimize rules:
1. Rules for bidirectional traffic flow between hosts. This means that instead of specifying source and destination for unidirectional flow, a rule for enabling traffic(bidirectional) between hosts would reduce the number of rules.
2. Similarly, instead of having rules for every protocol, we can use wildcard like * to allow or block all protocols between the pair of hosts. Or we can create a group of allowed protocols between the hosts.
3. In order to block the traffic from a subnet, we can add rules to block the subnet address(say, 10.0.2.0/24) instead of adding individual rules blocking all IPs in the subnet.
4. Also, in applications like the above example, where majority of traffic is allowed to pass except malicious IPs(Blacklist IPs, private IPs etc.), the default rule to pass all traffic would significantly reduce the rules on the firewall. In the case of the problem, the given approach would just need three rules.

3. Suppose the network operator intends to implement firewall policies in real time. How can she ensure that the pre-existing rules do not interfere with the firewall policy?

The network operator can use the priority field to set the priority of the new rules. The priorities are numbered from 0 to 66535. A higher value denotes higher priority. So, she can give higher priority to the new rules, so that the existing rules do not interfere with new rules. The new rules will be applied before the existing ones because of higher priority.

PART 3

1. Have the three hosts (H1, H2, and H3) ping the virtual IP and report the installed rule on the switches.



```
tions=CONTROLLER:65535
mininet> dpctl dump-flows
*** s1 ------------------------------------------------------------------------
 cookie=0x0, duration=84.684s, table=0, n_packets=5, n_bytes=490, priority=20,icmp,in_port="s1-eth1",nw_dst=10.0.0.42 actions=mod_nw_dst:10.0.0.4,output:"s1-eth4"
 cookie=0x0, duration=56.192s, table=0, n_packets=1, n_bytes=98, priority=20,icmp,in_port="s1-eth2",nw_dst=10.0.0.42 actions=mod_nw_dst:10.0.0.5,output:"s1-eth4"
 cookie=0x0, duration=31.353s, table=0, n_packets=1, n_bytes=98, priority=20,icmp,in_port="s1-eth3",nw_dst=10.0.0.42 actions=mod_nw_dst:10.0.0.4,output:"s1-eth4"
 cookie=0x0, duration=84.681s, table=0, n_packets=5, n_bytes=490, priority=20,icmp,in_port="s1-eth4",dl_dst=00:00:00:00:00:01,nw_src=10.0.0.4 actions=mod_nw_src:10.0.0.42,output:"s1-eth1"
 cookie=0x0, duration=56.187s, table=0, n_packets=1, n_bytes=98, priority=20,icmp,in_port="s1-eth4",dl_dst=00:00:00:00:00:02,nw_src=10.0.0.5 actions=mod_nw_src:10.0.0.42,output:"s1-eth2"
 cookie=0x0, duration=31.353s, table=0, n_packets=1, n_bytes=98, priority=20,icmp,in_port="s1-eth4",dl_dst=00:00:00:00:00:03,nw_src=10.0.0.4 actions=mod_nw_src:10.0.0.42,output:"s1-eth3"
 cookie=0x0, duration=83.672s, table=0, n_packets=0, n_bytes=0, priority=10,in_port="s1-eth1",dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:04 actions=output:"s1-eth4"
 cookie=0x0, duration=55.193s, table=0, n_packets=0, n_bytes=0, priority=10,in_port="s1-eth2",dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:05 actions=output:"s1-eth4"
 cookie=0x0, duration=31.357s, table=0, n_packets=1, n_bytes=42, priority=10,in_port="s1-eth3",dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:04 actions=output:"s1-eth4"
 cookie=0x0, duration=92.574s, table=0, n_packets=11, n_bytes=630, priority=0 actions=CONTROLLER:65535
*** s2 ------------------------------------------------------------------------
 cookie=0x0, duration=83.672s, table=0, n_packets=4, n_bytes=392, priority=10,in_port="s2-eth3",dl_src=00:00:00:00:00:01,dl_dst=00:00:00:00:00:04 actions=output:"s2-eth1"
 cookie=0x0, duration=83.668s, table=0, n_packets=4, n_bytes=392, priority=10,in_port="s2-eth1",dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:01 actions=output:"s2-eth3"
 cookie=0x0, duration=55.194s, table=0, n_packets=0, n_bytes=0, priority=10,in_port="s2-eth3",dl_src=00:00:00:00:00:02,dl_dst=00:00:00:00:00:05 actions=output:"s2-eth2"
 cookie=0x0, duration=55.193s, table=0, n_packets=0, n_bytes=0, priority=10,in_port="s2-eth2",dl_src=00:00:00:00:00:05,dl_dst=00:00:00:00:00:02 actions=output:"s2-eth3"
 cookie=0x0, duration=30.337s, table=0, n_packets=1, n_bytes=42, priority=10,in_port="s2-eth3",dl_src=00:00:00:00:00:03,dl_dst=00:00:00:00:00:04 actions=output:"s2-eth1"
 cookie=0x0, duration=30.331s, table=0, n_packets=0, n_bytes=0, priority=10,in_port="s2-eth1",dl_src=00:00:00:00:00:04,dl_dst=00:00:00:00:00:03 actions=output:"s2-eth3"
 cookie=0x0, duration=92.579s, table=0, n_packets=11, n_bytes=798, priority=0 actions=CONTROLLER:65535
mininet> 
```

2. If you were to implement a load balancing policy that considers the load on these servers, what additional steps would you take? [No need to implement it in the code, just describe the additional steps.]

I would consider the traffic destined to each server in some time frame say, t seconds. This can be done by monitoring the flow tables at the switch after every t seconds. The total number of packets destined to each server will be extracted from the flow tables in the given time frame. If the traffic is biased, then the new connections can be diverted to the less utilized server by mapping the virtual IP to the MAC of the less utilized server.